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Real-Time Multiple License Plate Recognition System

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Abstract: *License plate recognition system is one of the core technologies in intelligent traffic control. In this paper, a new and tunable algorithm which can detect multiple license plates in high resolution applications is proposed. The algorithm to the investigation and identification of the novel Iranian and some European countries plate, characterized by both inclusion of blue area on it and its geometric shape. Obviously, the suggested algorithm contains suitable velocity due to not making use of heavy pre-processing operation such as image-improving filters, edge-detection operation and omission of noise at the beginning stages. So the method recommended here is compatible with model-adaptation, i.e. using the very blue section of the plate. The present method indicates the fact that, if several plates are included in the image, this method can successfully manage to detect them. We evaluated our method on the two Persian single vehicle license plate data set that we obtained 99.33, 99% correct recognition rate respectively. Further we tested our algorithm on the Persian multiple vehicle license plate data set and we achieved 98% accuracy rate. Also we obtained approximately 99% accuracy in character recognition stage.*

Keywords: *Multiple license plate recognition, real-time; color space, pattern recognition*

I. INTRODUCTION

Automatic license plate recognition plays an important role in numerous real-life applications, such as unattended parking lots, security control of restricted areas, traffic law enforcement, congestion pricing, and automatic toll collection [1-6]. In the most of present methods, the conditions of environment and plate, affect on the performance of the method, therefore these methods have limitations. So, reaching the methods that offer the acceptable results is expected. A license plate recognition system generally consists of three main parts: 1) license plate recognition 2) characters segmentation 3) characters recognition [7]. Among these stages, the license plate recognition has a special sensitivity and is one of the most difficult stages in this process. To detect the region of car license plate, many techniques have been used. In [8] combination of edge statistics and mathematical morphology showed very good results, but it is time consuming and because of this problem, [9] uses block-base algorithm. In [10] a novel method called "N row distance" is implemented. This method scans an image with N row distance and counts the existent edges. If the number of the edges is greater than a threshold then the license plate is recognized, if not threshold have to be reduced and algorithm will be repeated. This method is fast and has good results for simple images. Disadvantage of this paper is that the edge based algorithms are sensitive to unwanted edges such as noise edges, and they fail when they are applied to complex images. A wavelet transform-based algorithm is used in [11] for extraction of the important features to be used for license plate location. This method can locate more than one license plate in an image. Methods which are symmetry based are mentioned in [12].

In [13] the plate is a location with the black background and white writings. In this way that, firstly, takes the image into the HSI and applies the capability of being black color of its background for this purpose, it uses a mask and segments the image according to HSI color intensity parameter and creates a binary image. For canceling probable noises, it uses the operation of erosion and dilation, then labels the existing candidates and for canceling the candidates which aren't the location of plate, it applies the geometric capability of the plate and other characters, then for recognizing a primary candidate, it uses the color intensity histogram, and recognizes the location of plate.

The current paper aims at investigation into and identification of the novel Iranian and some European countries plate characterized by both inclusion of blue area on it and its geometric shape. Figure 1 shows the sample license plate of these countries. Obviously, the suggested system contains suitable velocity due to not making use of heavy pre-processing operation such as image-improving filters, edge-detection operation and omission of noise at the beginning stages. So, the

recommended method of ours is compatible with model-adaptation, i.e., the very blue section of the plate so that the present method indicated the fact that if several plates are included in the image, the method can successfully manage to detect it. In section two the proposed algorithm is elaborated. In section three the practical result of the paper and in section four, conclusion is presented.

Figure 1: Sample of plates in some countries
a: Iran country b: France country
c: German country d: Polish country

II. PROPOSED METHOD

General diagram of the proposed algorithm is shown in Figure 2.

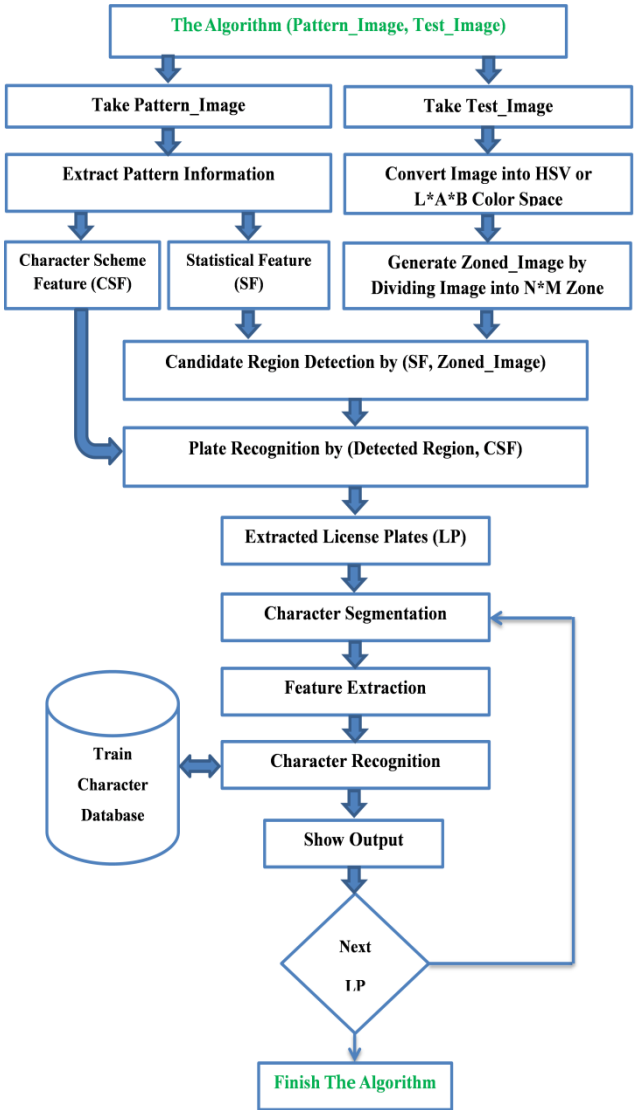

Figure 2: General diagram of the proposed algorithm

Our Proposed Algorithm is based on pattern recognition. The suggested algorithm is a robust and tunable algorithm that can be used for detection any kind of plate in the images. The algorithm needs two parameters; pattern and test image. The pattern parameter is used as an object to localizing in the test image. In this research we considered Iranian license plate as our patterns; Figure 1(a) shows these patterns. For detection pattern on test image at first time, the information such as Character Scheme Feature (CSF) and Color Feature (CF) in pattern parameters is computed. Then for finding the pattern (license plate) in test image, first the test image is converted to the HSV or L*A*B color spaces. Then instead of processing whole image region, the image is broken to list of preparatory zones and in order during frequent process, zones are selected. The existence a SF of pattern is investigated in it. For investigate of zones only its lip pixel used, that are consisted of 23.44% of zone pixels. Whenever a zone with pattern area is found, by investigation its top, down and side blocks and considering SF of pattern, the considerable place is selected as a candidate and supplemented to candidate region. Upper operation is continued to finishing of all zones.

A. Extracting Pattern Information

In this section the nominate pattern information is extracted for detection it in the test image. We considered Iranian license plate as our patterns. For obtaining statistical feature (SF) and character scheme feature (CSF) we considered Iranian license plate as two parts, Figure 3 shows these parts; and by Equation (1) and Equation (2) we extracted the SF and CSF feature respectively.

Figure 3: The CF and CSF parts of Iranian license plate country

$$CF = Ratio_{Blue_{part}} = \frac{Hight_{SF\ Region}}{Width_{SF\ Region}} \quad (1)$$

$$Jump_{Array\ [i]} = \sum_{j=1}^{n-1} [Image(i,j)\ XOR\ Image(i,j+1)]$$

for each i ∈ Image. row (m)

end for

CSF.K= mean (Jump_Array)
CSF.T= Count (Jump_Array>CSF.K) (2)

Where image is a pattern (like figure 1(a)) and m,n are the size of pattern image.

*B. HSV and L*A*B Color Space*

Even although RGB color space is ideal for monitor, it is unnatural for human being. For stance, recognizing how to make a color lighter in RGB color space is more difficult work. It is easier for human to use hue, saturation and brightness features for explanation [14]. The superior of this color space to RGB, is lack of relation between producer elements hue, saturation with brightness amount. Whereas plate number recognition system is made by subjectivity that human has from colors. So, use of suitable color space is necessary for carefulness in work.

A Lab color space is a color-opponent space with dimension L for lightness and A, B for the color-opponent dimensions, based on nonlinearly compressed CIE XYZ color space coordinates. This color space is better suited to many digital image manipulations than the RGB space, which is typically used in image editing programs. In our investigation as a practical result we achieved better result when we used HSV color space rather than L*A*B.

C. Candidate Region Detection

For determining the plate location, initially the input image is converted to the HSV color space. Then the image is broken to zones in N*M size and that N and M amount as a practical result is obtained in order 15,16. Figure 4(b) shows the result of operation of HSV color space for the image entered. After creating the lists from zones in order, evaluation starts from the bottom corner and left hand image area as the blue area lies in left hand and bottom corner. In evaluation of each zone only its lip pixels that it consist 23.44% of it are re-evaluated. If in the process, the blue pixel is found the evaluation process would be done for the whole pixel zone. Further, with the evaluation of it's upper and lower blocks we can find the steady blue area, retrieving its width and height. If the width and height retrieved of the blue area that is selected as a pattern is SF ($Ratio_{Blue_{part}}$), plate height is obtained equally with the$SF(Hight_{SF_{Region}}$). And its width is obtained by increasing the $SF(Width_{SF_{Region}}$)8 times. Figure 4(c) shows the result.

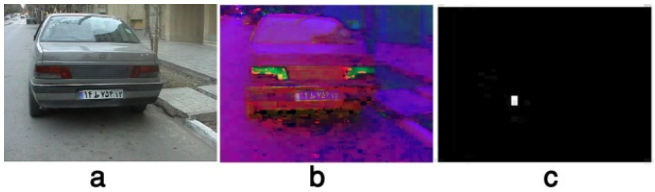

Figure 4: (a): entrance image in RGB mode (b): image in HSV mode (c): extracted plate SF region

By finding candidate area this area is added to plate candidates list and increase blocks that are in this area are omitted from preparatory blocks list and operation is done on reminder blocks. In this algorithm the worst state is happened if the plate isn't in image or it is scratched. In this state all blocks will be studied and therefore 23.44% of image will be processed.

D. Plate Recognition

In this step, first the exploited candidates from last step are labeled. And in a repeated process are evaluated the number of color jump. If evaluation of a candidate is successful and plate kind such as governmental, public, private is specified, this candidate considered as plate location and its tilt will be resolved.

In this step by the use of color jump and color kind of plate we determined that candidate as plate or not. With regard to the plate area consists of successive 8 characters and its color violence change rate is more than to other area we use these features for the plate specifying. For determining of a color change range, in every line the number of color change is counted from white color to black color or inverse. If the number of color change is more than CSF.K amount and successive line numbered more than CSF.T, this area as a plate area is considered. Figure 5 shows exploited plate from entrance image.

Figure 5: The image of extracted candidate

E. Character Segmentation and Recognition

In this paper from last step, the area that is exploited as a plate, first probable noising are solved, then plate image is complemented till its writing of plate inside is seen such white violence. Then this area is labeled and through the available regions, the regions that are bigger are stored as exploited characters in 60*30 sizes. Figure 6(a) shows the extracted plate after removing noise and Figure 6(b) shows its histograms.

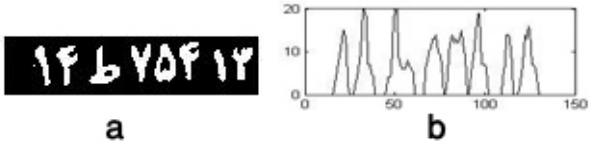

Figure 6: (a): extracted plate after removing the noise (b): histogram of extracted plate

The extracted characters are then recognized and the output is the license plate number. To recognition the characters of car license plate, many techniques have been used. In [15], the feature vector is generated

by dividing the binary character into blocks of 3×3 pixels. Then, the number of black pixels in each block is counted. In [16], the feature vector is generated by dividing the binary character after a thinning operation into 3 × 3 blocks and counting the number of elements that have 0°, 45°, 90°, and 135° inclination. In [17], the character is scanned along a central axis. This central axis is the connection between the upper bound horizontal central moment and lower bound horizontal central moment. Then the number of transitions from character to background and spacing between them form a feature vector for each character. This method is invariant to the rotation of the character because the same feature vector is generated. Template matching is performed in [18] - [21] after resizing the extracted character into the same size. Several similarity measuring techniques are defined in the literature. Some of them are Mahalanobis distance and the Bayes decision technique [19], Jaccard value [20], Hausdorff distance [21]. In [22] and [23] the feature vector is generated by dividing the binary character into blocks of pixels. Then, the angle and distance of black pixels in each block is extracted.

In this system, we computed the features based on chain-code directional frequencies of contour pixels of the images as follows: First we found the bounding box (minimum rectangle containing the hand gesture) of each input image which is a two-tone image. Then for better result and independency of features to size and position (invariant to scale and translation), we converted each image (located in bounding box) to a normal size of 49×49 pixels. We chose this normalized value based of various experiments and a statistical study. In Figure 7(a), a normalized image with its bounding box is shown. We extracted the contour of the normalized image Figure 7(b).

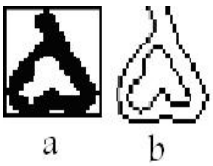

Figure 7: (a): Bounding box of a normalized image (b): Digit '5' in Persian and its contour

We scanned the image contour horizontally by keeping a window-map of size 7×7 on the image from the top left most point to down right most point (49 no overlapped blocks). For each block the chain code frequencies for all 8 directions were computed (8 directions were shown in Figure 8(a)). Instead of expressing the features in terms of 8 directions, we have proposed to simplify the features into 4 sets corresponding to 4 directions [Figure 8(b)]: i) horizontal direction code (direction 0 and 4), ii) vertical direction code (direction 2 and 6) iii) principal diagonal direction code (direction 1 and 5) and iv) off diagonal direction code (direction 3 and 7). Thus, in each block, we got four values representing the frequencies of these four directions and these values were used as features (local contour direction values). To extract features, we considered 49 (7×7) uniform blocks in each image and we computed four features in each block so we got 49×4=196 features for each image.

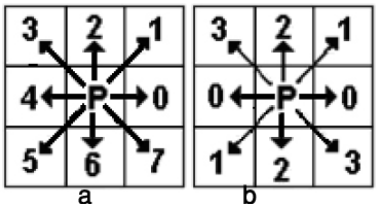

Figure 8: (a): 8 direction code (b): 4 direction codes obtained from 8 directions

F. Character Recognition by SVM

Support vector machines (SVMs) [24] are very popular and powerful in pattern learning because of supporting high dimensional data and at the same time, providing good generalization properties. Moreover, SVMs have many usages in pattern recognition and data mining applications such as text categorization [25], 3D object detection [26], face recognition [27]. At the beginning, SVM was formulated for two-class (binary) classification problems and then it extended two most popular group: one-against-all (OAA) and the one-against-one (OAO). In this paper we used OAA approach for character recognition stage.

III. RESULT AND IMPLEMENTATION

In this part the practical result of proposed method for license plate recognition system compared with contemporary methods are detailed. Our suggestive method have been done on Intel Core i3-2330M CPU, 2.20 GHz with 2 GB RAM under Matlab environment. Figure 9 shows the worked system.

Figure 9: our proposed license plate recognition system

The suggestive method is robustness against parameters such as: the different size and situation of plate in image, the view of videotaping and different light situation in videotaping, injuries and pollution of plate.

A. Evaluation of License Plate Location Stage

For evaluation of our method, first, the data set that is mentioned in [28] and [29] is considered. This data set consists of 150 colorful images in 640*480 sizes. These images are variety in point of view, good light balance, various distances and various backgrounds. The result of the proposed method for license plate recognition compared with these methods is shown in Table I.

TABLE I: Accuracy rate of proposed method on first databases

Method	Correct Plate Recognition	Incorrect plate Recognition	Percent Efficiency
R. Azad et al. [28]	148	2	98.66%
S.H.M Kasaei et al. [29]	146	4	97.30%
Our Method	149	1	99.33%

The second data set that we used for our proposed method is mentioned in [7] consist of 100 images that are captured by a 2 mega-pixel camera of mobile phone (Nokia 5230) from front view of car. These images are 640*480 sizes, RGB mode, variety in point of view, various light condition, various distances and backgrounds. The result of the proposed method that applied on the second data set for license plate recognition is shown in Table II.

TABLE II: Accuracy rate of proposed method on second databases

Method	Correct Plate Recognition	Incorrect plate Recognition	Percent Efficiency
R. Azad et al. [7]	98	2	98%
Our Method	99	1	99%

According to the previous license plate recognition approaches, there is not a popular database for multiple license plate recognition system to evaluate the performance of its methods. Especially for Iranian vehicle data set, because most of the proposed approach attempts to find single plate in the image. In this respect, to prove the quality of proposed approach, 100 images of 3 mega-pixel resolution are captured and used by our team form front, back and side views of the cars. These images are of diverse sizes, RGB mode, variety in point of view; various light conditions, various distances, complex backgrounds and contain more than one car. The result of the proposed method that applied on the third data set for license plate recognition is shown in Table III.

TABLE III: Accuracy rate of proposed method on third databases

Number of Car in each image	Number of images	Whole Number of License Plates	Correct Plate Recognition	Percent Efficiency
Two cars	50	100	99	99%
Three cars	50	150	146	97.33%

B. Evaluation of Character Recognition Stage

In the table IV, our method is compared with normal factoring method represented in [14], K-Nearest- Neighbor (KNN) method [7] and template matching mentioned in [29] that all of them used first dataset for evaluation of their works.

TABLE IV: Accuracy rate of proposed on character recognition stage

Total character Images	Method	Correct Recognition	Efficiency
1200	R. Azad et al. [7]	1188	99%
	R. Azad et al. [14]	1164	97%
	S.H.M Kasaei et al. [29]	1104	92%
	Proposed method	1194	99.50%

Further we achieved 100% and 98% accuracy rate respectively when we evaluated our method on second and third data set. Table V shows the information process of our method.

TABLE V: Information process of the proposed method

PROCESS INFORMATION	Minimum	Maximum	Average
Process Time for License Plate Recognition	0.012110	0.066235	0.030123
Number of Detected Candidate	1	7	3

Figure 10 shows some of the detection results, where the license plates are circled by white boxes. From the examples, we may see that our algorithm can detect the license plates with various sizes, positions and colors from various backgrounds.

Figure 10: Detection results of some license plate by the proposed method

IV. CONCLUSION AND FUTURE WORK

In this paper, a new and tunable algorithm which can detect multiple license plates in high resolution applications is proposed. For detection license plate on test image at first time, the information such as character scheme feature (CSF) and statistical feature (SF) in pattern parameters is computed. Then for finding the pattern (license plate) in test image, first the test image is converted to the HSV or L*A*B color spaces. Then instead of processing whole image region, the image is broken to list of preparatory zones and in order during frequent process, zones are selected. The existence a SF of pattern is investigated in it. For investigate of zones only its lip pixel used, that are consisted of 23.44% of zone pixels. Whenever a zone with pattern area is found, by investigation its top, down and side blocks and considering SF of pattern, the considerable place is selected as a candidate and supplemented to candidate region. Finally by color jump and CFS testing the real plate location is extracted. We evaluated our method on the two Persian single vehicle license plate data set that we obtained 99.33, 99% correct recognition rate respectively. Further we tested our algorithm on the Persian multiple vehicle license plate data set and we achieved approximately 98% accuracy rate. Also we obtained approximately 99% accuracy in character recognition stage. This work is implemented for still images, for future work we have planned to extend it for license plate detection and recognition in video stream.

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